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P.E.S. College of Engineering, Mandya - 571 401

(An Autonomous Institution affiliated to VTU, Belagavi)

Sixth Semester, B.E. - Electrical and Electronics Engineering

Semester End Examination; May/June - 2018

Electrical Machine Design

Time: 3 hrs *Max. Marks: 100*

***Note**: Answer **FIVE** full questions, selecting **ONE** full question from each unit.*

UNIT - I

1 a. List the desirable properties of good insulting material employed in electrical machines. List also the classification insulating materials with their thermal ratings. 6

b. Enumerate the required properties of magnetic materials used in the manufacture of electrical machines. 4

c. Calculate the main dimensions for a 7.5 kW, 4 pole 1000 rpm, 220 V DC shunt motor. Given that full load efficiency = 0.83, maximum air gap flux density = 0.9 Tesla, specific electric loading = 300 Ac/cm field form factor = 0.7. Assume that the maximum efficiency occurs at full load. Field current is equal to 2.5% rated current. 10

2 a. Explain the differences between classroom design and industrial design. 6

b. List the factors to be considered for selection of number of poles in DC machines. 4

c. Determine suitable values for the core length external diameter of the armature and suitable number of poles for a 1500 kW, 500 V, 250 rpm DC generator. Assume suitable value for specific electric and magnetic loadings and other design constants. State the reasons for your choice. 10

UNIT - II

3 a. With a neat figure, explain the slot insulation details of a DC machine armature. 8

b. A 250 kW, 500 V, 6 pole 600 rpm DC generator is built with an armature of 0.75 m and core length of 0.3 m. The lap connected armature has 720 conductors. Using the data obtained from this machine, determine the armature diameter, core length number of armature slots, armature conductors and commutator segments for a 350 kW, 440 V, 720 rpm 6 pole dc generator. Assume a square pole face with a ratio of pole arc to pole pitch as 0.66. The diameter of commutator is 0.7 times of armature diameter. The pitch of commutator segments should not be less than 0.4 cm. The voltage between adjacent segments should not exceed 15 V at no load. The generated voltage is 1.05 times the rated terminal voltage. 12

4 a. Explain the air gap irregularities to be considered for calculation of ampere-turns of the air gap. 10

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b. Find the ampere turns per pole required for the air gap of a 6 pole lap connected DC generator with the following particulars; No load voltage = 500 V, air gap length = 0.5 cm, pole pitch = 50 cm, pole arc = 33 cm, armature core length = 30 cm, width of the slot = 1.3 cm, speed = 300 rpm. number of ventilating ducts = 5, each 1 m wide, number of slots = 90, No. of conductors / slot = 16, Carter's coefficient for slots $\delta_s = 0.66$ carter's coefficient for ventilating ducts $\delta_v = 0.72$. 10

UNIT - III

5 a. With usual notations, show that the output of a 3ϕ core type transformer is directly proportional to the 4th power of its linear dimensions. 6

b. Explain the design considerations to be taken into account in design of power transformers. 4

c. Calculate the approximate over all dimensions of the magnetic circuit for a 200 kVA, 6600/440 V, 50 Hz, 3ϕ core type transformer. The following design data may be used voltage / turn = 10 V, maximum flux density = 1.3 wb / m^2; current density = 2.5 A/mm^2, window space factor = 0.3. Overall height = over all width; stacking factor = 0.3 Use 3 stepped core. 10

6 a. Derive an expression for the leakage reactance of core type transformer having coils of equal length. 6

b. A 15000 kVA, 33/6.6 kV, 3ϕ, Y/Δ, Core type transformer has the following data; Net iron area of each limb = 1.5×10^3 cm^2
Net area of yoke = 1.8×10^3 cm^2
Mean length of flux path in each limb = 2.3 m
Mean length of flux path in each yoke = 1.6 m
No. of turns in HV winding = 450
mmf / meter = 260 AT/m at a flux density of 1.06 wb/m^2;
mmf/meter = 560 AT/m at a flux density of 1.27 wb/m^2,
specific loss at 1.06 wb/m^2 = 1.4 w/kg;
specific loss at 1.27 wb /m^2 = 2.25 w/kg.
Density of steel used = 7.8×10^3 kg/m^3. Calculate the no load current. 14

UNIT - IV

7 a. With usual notations, derive the output equation of an induction motor when the output is specified in HP? 8

b. A 20 HP, 400 V, 4 Pole, 50 Hz, 3ϕ, induction motor is built with a stator bore of 25 cm and a core length of 16 cm. Specific electric loading is 230 Ac/cm. Using the design data of this machine determine the core dimensions, number of slots, number of stator conductors and copper loss for a 15 HP, 460 V, 6 pole, 50 Hz induction motor. Assume full load efficiency of 0.84 and power factor of 0.83 for each machine. Consider fractional slot winding for second machine. 12

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8 a. Explain the factors to be considered while selecting the number of slots for a squirrel cage rotor. 6

b. List the factors to be considered for estimating the length of the air gap in an induction motor. 4

c. A 90 kW, 500 V, 50 Hz, 3-phase 8 pole induction motor has a star connected stator winding accommodated in 63 slots with 6 conductors / slot. If the slip ring voltage on open circuit is to be about 400 V, design a suitable rotor winding stating; 10

i) Number of slots ii) Number of conductors per slot

iii) Coil span iv) Slip ring voltage on open circuit

v) Approximate full load current / phase in rotor

Assume efficiency as 90% and power factor = 0.86.

UNIT - V

9 a. Define short circuit ratio. Show that it is inversly proportional to synchronous reactance. Explain the effect of short circuit ratio on the machine performance. 10

b. Extimate the main dimensions of 1800 kVA, 50 Hz, 3ϕ, 187.5 rpm water wheel generator. The specific magnetic loading is 0.8wb/m^2, specific electric loading is 26000 Ac/m pole arc to pole pitch ratio is 0.66. Calculate the peripheral velocity. Justify the estimation of D and L. 10

10 a. Giving reasons suggest the modifications to be mode in the values of,

i) B_{av} to improve the stability limit of synchronous machines

ii) q when the machine is to be designed for higher voltage rating

iii) Number of stator slots to decrease the leakage reactance of synchronous machine 10

iv) Stator slot dimension to decrease the severity of short circuit current in case of non salient pole synchronous machines.

b. Each pole of an alternator is required to produce 18000 ampere-turns. The air gap flux is 0.2 wb and the flux density in the salient pole core of circular cross section is 1.5 T. The leakage coefficient is 1.2. The radial thickness of the coil is 15cm and can dissipate 0.05 watts/cm^2 of outer surface. Determine the number of turns and height of the coil. Voltage across each coil can be taken as 60 volts. Space factor = 0.7, thickness of insulation as 0.5 cm and resistivity as $2x10^{-6}\ \Omega$/cm. 10

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